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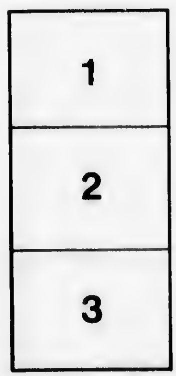
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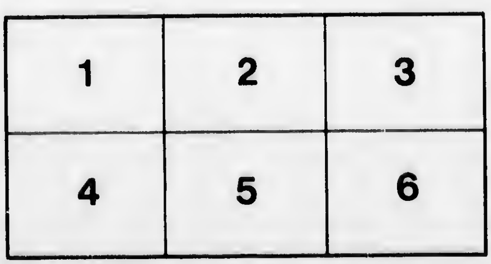
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Methods of Maintaining The Fertility of Land in Orchards.

BY WM. SAUNDERS, LL.D., F.R.S.C.

PAPER READ BEFORE
THE ONTARIO FRUIT GROWERS' ASSOCIATION
DECEMBER, 1897.

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METHODS OF MAINTAINING THE FERTILITY OF LAND IN ORCHARDS.

By Wm. Saunders, LL.D., F.R.S.C., Director of Dominion Experimental Farms.

It is always a source of great pleasure for me to be with you at your annual meetings. I look back with very much interest to my early connection with this Fruit Growers' Association. It may not be known to many of you that I was one of the earliest directors. I believe I was made a director shortly after I was made a member. The difficulty in getting directors in those days arose partly from the fact that they had to pay their own expenses and hotel bills, and in the early times, before we had any Government grant or any endorsation whatever from the public authorities, the work of the Association was carried on mainly through the individual efforts of the members who took an interest in it. I think it must be about thirty years ago when I first had the honor of occupying the position of a director of this Association, associated with my old friends Arnold and Dempsey, and others who have passed away since then to the better land. When the Government proposed to take into its care the Fruit Growers' Association under the Agricultural Act, and give it an annual grant—I think the first annual grant was $400 or $500—we thought a great feat had been accomplished. At that time, from lack of funds and having no journal or annual report to bring our work before the Canadian public, it was naturally carried on with much difficulty. Still we were all enthusiastic in it, we all put our shoulders to the wheel and worked most harmoniously together for the common good, and from those early beginnings this Association has gradually grown to its present position of prominence and importance. I mention those early matters to show what a strong link there is which holds me to this Association, and the reason why I always take such a pleasure in being present with you. I had the honor for five or six years of being president of the Association, and during that time did all I could to further the interests of the work; indeed, I was occupying that honorable position at the time I was appointed to my present office as Director of Experimental Farms, and had to resign in order to take the work I am now carrying on. My sympathies have always been and still are with the fruit growers and horticulturists of this country quite as strong as with the agriculturists, and I am very glad to have the opportunity of bringing before you to-day a subject which I hope will prove helpful to you, that is, to put in a clear common sense sort of way—so that every farmer can understand it—what should be added to the soil in order to replace those elements which are taken from it in the growing of fruit.

It is the chief aim of all intelligent cultivators of the soil, whether engaged in raising cereal or fodder crops or fruit, to so treat the land as to secure satisfactory crops and at the same time maintain the fertility of the soil so that good crops may be continued indefinitely.

Formation and Nature of Soils.

All soils are the result of the disintegration of rocks by the forces of nature, and the intermixture therewith of organic matter resulting from the decay of animal and vegetable remains. Soils vary much in fertility partly owing to difference in the composition of the rocks from which they have been formed, partly to their mechanical condition and texture and also to the variable proportion of organic matter they contain. These variations are commonly distinguished by special terms, such as clayey, loamy, sandy or gravelly soils, indicating the materials which form the larger proportion of their bulk. The productiveness of a soil also depends partly on its power of holding water and of drawing supplies of moisture from below. Water, which in the soil is usually more or less charged with carbonic acid gas is the universal solvent which nature employs to convey food to the rootlets of plants. A good loamy soil will hold much more moisture than either clay or sand, and hence usually produces better results in cultivation.

Stores of Fertility in Soils.

All soils contain more or less plant food in a soluble form, which is immediately available for the use of growing plants. On the other hand there is always a large proportion of the elements of fertility which exist in the soil in a comparatively insoluble form, which can only be made available gradually by thorough cultivation of the land and exposing its particles to the beneficial action of the air. By thorough working, the power which the soil has of retaining moisture may be increased and the loss of water by evaporation from its surface lessened. Soil is nature's great store-house of fertility in which is laid up treasures more valuable to national life than gold. There are many mineral constituents in every soil, and quite a number of these are taken up by living plants, but in most instances the quantities used are small, and the store laid up in the land ample. There are, however, three ingredients which plants take in comparatively large proportions from the soil, which must in some measure be restored to it if its fertility is to be maintained, these are nitrogen, potash and phosphoric acid. All arable lands contain these important ingredients, and usually in considerable proportions.

It is estimated that an acre of soil a foot deep weighs on an average 3,500,000 pounds, and that good ordinary loam in Europe will contain, on an average, not less than 3,500 pounds per acre of nitrogen, and sometimes more than that. The quantity of potash in the same area usually ranges from 5,000 to 8,000 pounds, and of phosphoric acid from 3,000 to 6,000 pounds.

From the analyses of soils which have been made by Mr. F. T. Shutt, Chemist of the Experimental Farms, during the past few years, many of them representing large areas, it would appear that the soils of Canada compare favorably with those of Europe in their richness in these important constituents. Those analyzed from different parts of Eastern Canada have average per acre as follows: nitrogen 6,200 pounds, potash 6,500 pounds, phosphoric acid 3,600 pounds, while the average of those examined from the Northwest plains give over 10,000 pounds per acre of nitrogen, 10,500 pounds of potash, and 5,000 pounds of phosphoric acid.

Elements Appropriated for the Production of Apple Wood.

Trees during their growth take a very large part of their substance from the air. The carbon dioxide or carbonic acid gas which animal life everywhere is constantly exhaling is absorbed by the leaves of plants and trees and converted into woody tissue and starchy and saccharine material so necessary for the food of animals. If you burn a piece of apple tree wood weighing 100 pounds you find as a result less than two pounds of ashes, 1.29%. The combustible matter destroyed with the exception of a small proportion of nitrogen has all been taken from the air. These ashes include all the mineral matter taken from the soil, and are said to contain about twelve per cent. of potash and about four and a half per cent. of phosphoric acid, with a much larger proportion of lime. On this basis an apple tree would take from the soil for the production of 100 pounds weight of its wood less than two and a half ounces of potash, about one ounce of phosphoric acid, and probably not more than five or six ounces of nitrogen.

Constituents of Apple Leaves.

Let us next consider the constituents of the leaves which, however, are eventually nearly all returned to the soil by their fall and gradual decay. The leaves of several varieties of apple trees have been analyzed by the Chemist of the experimental farms at different stages of their growth with the following results. Gathered on the 25th of May, when they were scarcely fully expanded, each 100 pounds contained an average of about twelve ounces of nitrogen, a little more than four ounces of potash, and less than four ounces of phosphoric acid. The mature leaves collected on the 20th September were found to contain a somewhat larger percentage of nitrogen and potash and a smaller proportion of phosphoric acid, about fourteen ounces of nitrogen, six ounces of potash, and three ounces of phosphoric acid, with fourteen ounces of lime in each 100 pounds of leaves.

Composition of the Fruit.

The fruit of the apple consists mainly of juice, which forms more than eighty per cent of its weight, and when this is expressed we have a residue which cider makers call pomace, composed of the compressed cellular structure of the fruit with the cores, seeds and skin with some of the flavoring material. The juice consists of water with malic acid varying in proportion in different varieties of apples from one quarter to one and a quarter per cent., and sugar from six to twelve per cent., with a little flavoring material. Everything in the juice excepting the water is compounded by the tree from the gases taken from the air, and hence there is no drain on the soil in the formation of this material.

In the pomace will be found the cores and seeds and these latter are rich in nitrogen, and the formation and maturing of the seed is a considerable tax on the vital forces of the tree. For this reason heavy crops are much less trying to the vigor of the tree if the fruit be thinned. The fruit produced is thus improved in size and quality, and the capacity of the tree for future production economized. Apple pomace contains in every 100 pounds about four and a half ounces of nitrogen, two ounces of potash and less than one-third of an ounce of phosphoric acid.

Having considered the composition of the wood, leaves and fruit of the tree, we shall next consider how much of the fertilizing constituents referred to are taken from the soil in bringing the tree to maturity and in the annual production of the leaves and fruit. Suppose we estimate the weight of the trunk and branches of the tree at 1,000 pounds—which is only a rough guess—and that we have thirty such trees planted thirty-eight by thirty-eight feet on an acre, these will have taken from the soil to produce their wood growth from three to four pounds per tree of nitrogen, (ninety to one hundred and twenty pounds in all) and not more than twenty-five ounces of potash and ten ounces of phosphoric acid, equal to about forty-six pounds of the former and eighteen pounds of the latter per acre. This includes all of these important fertilizers which are taken from the soil for the entire growth of the woody structure of the trees on one acre of orchard.

The Leaves.

I know of no basis on which an estimate of the weight of leaves on an apple tree can be founded. It will serve our present purpose however to roughly place them at 100 pounds. On this calculation thirty trees will draw annually from the soil about twenty-four pounds of nitrogen, nine pounds of potash and seven pounds of phosphoric acid, with about eighteen pounds of lime. Since however as already remarked the leaves are always allowed to fall on the ground, where they gradually decay and are most of them returned to the soil, it would be a liberal estimate to allow one-half of the ingredients taken as lost to the land.

The Fruit.

Supposing the thirty trees per acre in the orchard to produce an annual crop of six barrels per tree of 130 pounds each, or 180 barrels, 23,400 pounds per acre, there would be taken from the soil for the growth of the fruit crop to maturity about thirteen pounds of nitrogen, six pounds of potash, and less than one pound of phosphoric acid.

The Waste and How it May be Returned.

In estimating the total withdrawal of fertilizing constituents from the soil as the amounts are small, we may venture to add to the annual drain on the land for the growth of the leaves and fruit, one-tenth of the quantities required for the entire growth of the woody portion of the trees, as follows:

—	Nitrogen.		Potash.		Phosporic acid.	
	lbs.	oz.	lbs.	oz.	lbs.	oz.
For $\frac{1}{10}$ of the total growth of the wood	12		4	10	1	14
For the waste of half the annual growth of the leaves	12	..	4	8	3	8
For the annual waste in the production of the fruit	13	..	6	..	1	..
Total	37	..	15	2	6	6

All the ingredients taken from the land may be replaced by the use of barn-yard manure, each ton of which of average quality contains while in the fresh condition from eight to ten pounds of nitrogen, ten to fifteen pounds of potash and from six to eight pounds of phosphoric acid. If the manure has been rotted under favourable conditions the proportions of the fertilizing constitutents will be somewhat increased. A dressing of about fifteen tons of manure every three years would more than restore the full quantity of nitrogen and more than three times the quantity of potash and phosphoric acid which has been taken from the land. It must however be borne in mind that the active feeding roots of the trees do not cover the entire ground and that they must find all that they require within the area of their distribution hence the return should be liberal.

Nitrogen may be more economically applied by the plowing under of green clover. A fair crop of this sown in the spring and plowed under late in the autumn will give to the soil from 100 to 150 pounds of nitrogen, and if left on the orchard as a cover crop and plowed under the following spring, from eighty to 100 pounds per acre. This crop will also gather potash from the soil and subsoil and present it in available form for the use of subsequent crops to the extent of 100 to 150 pounds per acre and phoshoric acid from thirty to thirty-five pounds. The nitrogen which the clover crop supplies to the soil is taken largely from the air and the fruit grower thus obtains assistance from nature in his endeavours to maintain the fertility of his land. An unlimited store of this valuable element exists in the air which is composed of four parts by weight of nitrogen with one part of oxygen and clover in common with other leguminous plants, has the power of taking in and storing this element in its tissues. This work is said to be done through the agency of colonies of bacteria located in the small gall-like swellings, so common on the roots of thrifty growing clover plants. The roots of clover extend over a wide area and penetrate to a great depth in the subsoil and they are thus able to draw upon supplies of plant food lying beyond the reach of other crops and in this way this plant acts as a permanent enricher of the soil. A careful study of the root system of red clover, has shown that plants one month old have roots extending seven inches into the ground that at two months some of the roots had reached a depth of two feet, and at four months to a depth of four to five feet. In addition to the gain of the fertilizers referred to, the organic matter in the roots and tops of the clover plowed under, improves the texture of the soil and makes it more retentive of moisture. The growing clover also acts as a catch crop during the summer and autumn and appropriates the nitrogenous fertilizers which are brought down by the rain and which when falling on bare ground, on account of their ready solubility pass through the soil and are lost in the drainage waters.

Nitrogen may also be conveniently given in the form of nitrate of soda. This occurs in large beds in Peru, and other parts of South America, mixed with common salt and earthy matter from which it is extracted and purified. Each 100 pounds furnishes about fifteen and a half pounds of nitrogen to the soil. The quantity usually recommended is from 100 to 200 pounds per acre. As this salt is very soluble and easily wasted by leaching, it should always be used as a top dressing, and it is more economical to divide the quantity to be used into two or three portions and apply them at intervals of one or two weeks.

Sulphate of ammonia is another source of nitrogen. It is a product made from gas liquors and is more expensive than the nitrate of soda. Each 100 pounds of the sulphate of ammonia supplies twenty pounds of nitrogen to the soil. Other sources of nitrogen are dried blood which contains from ten to ten and a half per cent., fish waste containing from eight to ten per cent. and guano.

Sources of Potash.

Probably the cheapest source of potash is unleached wood ashes. These contain from five to six per cent of potash, and about two per cent of phosphate of lime. When leached they contain the same proportion of phosphate of lime but the proportion of potash is reduced to about one to one and a quarter per cent. Ashes usually contain also a considerable proportion of lime. Large quantities of unleached ashes are still shipped every year from Canada to the Eastern States where they are sold to farmers at from $13 to $18 per ton.

Kainit is a very important source of potash. This is a a crude natural potash salt, found in large quantities at Strassfurt, in North Germany, lying in beds more than 1,000 feet below the surface. It contains about twenty-two to twenty-three per cent, of potassium sulphate, equal to about twelve per cent. of pure potash. This is said to be associated with magnesium sulphate, about seventeen per cent. magnesium chloride about fourteen per cent., and common salt, sodium chloride twenty-seven per cent. The quantity of this crude salt recommended to be used, is from 300 to 800 pounds per acre. In another stratum of these valuable potash deposits at Strassfurt, a layer is found consisting mainly of muriate of potash and chloride of magnesium. This is known in commerce as carnallit and contains about the same proportion of potash as kainit. This deposit ranges from fifty to 150 feet thick, and from it most of the potash salts of higher grade are manufactured, such as the muriates and sulphates of potash, each containing about fifty per cent. of potash. Some idea of the importance of these potash deposits may be formed from the fact that more than 9,000 men are employed as miners and labourers in connection with the works. The prices at which these potash salts are usually sold are about as follows, kainit $12 to $15 per ton, muriate of potash $42 to $45 per ton, and sulphate of potash $42 to $50 per ton.

Sources of Phosphoric Acid.

Phosphoric acid is the third of the substances referred to as largely used by growing plants. The chief sources from which this material is obtained are the bones of animals, mineral phosphate of lime or apatite, and basic slag a waste product formed during the purification of iron.

The bones of land animals in their fresh condition contain about forty-six per cent. of phosphate of lime, four per cent. of carbonate of lime, a small proportion about two per cent. of potash and soda, and forty-eight per cent. of gelatine, fat and water. The gelatine contains from three to five per cent. of nitrogen, and the phosphate of lime from eighteen to twenty-three per cent. of phosphoric acid. The phosphate of lime as it exists in bones is insoluble in water and, but very slowly soluble in the soil. It is rendered wholly and quickly soluble when it is treated with sulphuric acid which changes the phosphate to the superphosphate. Bones may also be reduced by the use of unleached ashes, placing the bones whole or coarsely ground in layers in a suitable vessel and covering them with layers of ashes mixed with about one-eighth of their weight of freshly slacked lime and the whole moistened with water. The ashes being rendered still more caustic by the lime acts on the bones and gradually softens them until they can be crushed between the fingers to a soap-like mass. When reduced to this condition the compound may be mixed with dry muck or loam and applied to the land—100 pounds of hard wood ashes are said to be sufficient to reduce about 100 pounds of bones.

Phosphoric acid may also be supplied in the form of superphosphate of lime made from the mineral phosphate. This as supplied by the manufacturers usually contains from eight to ten per cent. in the lower grades, and thirteen to twenty per cent. of soluble phosphoric acid in the higher grades.

Thomas' slag, known also as basic slag or odorless phosphate, is a third source of phosphoric acid. Many iron ores contain minute quantities of phosphorus which reduces the quality of the ore. In the manufacture of such iron into steel, the process is so conducted that a chemical action takes place in the presence of lime at a very high temperature whereby the phosphorus in the iron is converted into phosphoric acid, and combined with lime forming a phosphate of lime. This is said to be easily decomposed and rendered soluble by the products arising from decomposing humus in the soil and is thus presented to the rootlets of plants in a form easy of assimilation. It is stated that the German factories now turn out about 400,000 tons of this slag annually, and a considerable quantity is also produced in Great Britain and the United States. The phosphoric acid in this waste product is said to be present in the proportion of from thirteen to twenty-one per cent. The slag also contains about fifty per cent. of lime and varying proportions of oxide of iron, magnesia and silica. It is odorless and tasteless.

Exhaustion Produced by Crops of Fruit.

The exhaustion of the soil seems to be greater in all cases from the production of the fruit than it is from the growth of the substance of the tree or vine. The ashes of the pear according to Wolff of Germany contains a little more than twice the quantity of potash that is found in the apple, the proportion of phosphoric acid is also one-third larger. In the fruit of the plum the potash is given as a little higher than that of the pear, and the phosphoric acid the same as in that fruit, whereas in the fruit of the cherry the proportion of potash is the same as that in the pear, and the proportion of phosphoric acid somewhat larger. It should not be forgotten that in the growing of all these fruits the drafts on the soil for potash are heavy, and hence this element should be supplied with a liberal hand.

It seems when you look at the figures I have given you that almost any soil, however poor, ought to continue to grow good crops of apples for a long time, seeing the large stores of the elements of fertility which are laid up in the land ; but you must consider the importance of the point I have already mentioned, that the roots of your trees occupy only a limited area, that they must take all the material they require from this limited area ; and hence the importance of treating your soil liberally and regularly with such things as careful analyses have shown are really taken away from your land, and which makes the land poorer every season you grow your fruit unless you take the pains to restore to that land an equivalent.

The peach ranks about with the plum in its consumption of potash but uses twice the quantity of phosphoric acid, whereas in the production of grapes the soil is drawn on to the extent of three pounds of potash, per 1,000 pounds of fruit and fourteen ounces of phosphoric acid. While the vine uses these elements of fertility freely in the production of its fruit it uses only about one-fourth this quantity in producing the wood and branches.

The raspberry and blackberry are said to consume one-fifth less potash than that of the apple for the same weight of fruit, and the strawberry according to the analysis of Dr. Goessman contains about two pounds twelve ounces of potash for every 1,000 pounds of fruit, and about fourteen ounces of phosphoric acid. The strawberry plant according to the analysis of the Chemist of the experimental farms consumes about five pounds of nitrogen, five and three quarter pounds of potash and one and four-tenth pounds of phosphoric acid for each thousand pounds weight.

This subject is a very important one, and I hope I have made it plain. The soil is the fruit grower's savings bank. There he has stored a large amount of capital. If he uses that capital carefully, if he returns—as he would if he wanted to keep up his savings bank balance—something equivalent to the drafts he makes on it, or a little more, instead of having his account grow poorer from year to year, he will have it become better and richer, his land will be in better condition to continue to give him good crops, and considering the enormous productiveness which is attained by this intensive method of agriculture, he can well afford to deal with the soil in a liberal way. I thank you for the very kind attention you have given me under such unfavorable conditions of voice. (Applause).